Remarks

Claims 1-9, 13-19, and 28-46, and 56-61 are pending in the application. Claims 10-12, 20-27, and 47-55 were withdrawn from consideration based on an election of species requirement. Applicant requests that these claims be rejoined to the application if generic claims are allowed. No new matter has been added by virtue of this amendment. Reconsideration of the application in view of this response is requested.

Applicant thanks the Examiner for the allowance of claims 29, 35, 36, and 39 if rewritten in independent form.

Applicant requests reconsideration of the decision to make the office action final in view of the new grounds for the rejection.

Claim Rejections-- 35 U.S.C. § 103(a)

The Examiner rejects claim 1-9, 13-19, and 28, 30-34, 37, 38, 40-46, and 56-61 under 35 U.S.C. § 103(a), as being unpatentable over Sokal in view of Shenai. The Examiner states that "claims 1-9, 13-19,28,30-34,37,38,40-46, and 56-61 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sokal et al. 3,919,656 (Sokal) in view of Shenai et al. 5,914,513 (Shenai). Figures 8a and 8b of Sokal discloses a power amplifier having a power amplifier Q with a tuned output network 9. Note that the driver 2 clearly adjusts/modulates the signals to the power amplifier, as this is what a driver does by definition. The reactive components are adapted to be tuned to a selected frequency by the tuning signal applied to the tuning input. Sokal teaches that variable reactive elements can be utilized in the filter **but is silent on the exact variable element**. As would have been well known to one of ordinary skill in the art, an electronically controlled reactive element is a conventional means for forming a variable reactive element. In fact Shenai of record discloses such a conventional means and is in fact an art recognized equivalent to C4 in Sokal. Accordingly, it would have been obvious to one of ordinary skill in the art at the time of the invention to use electronic controlled reactive elements because, as the Sokal reference is silent on the exact variable reactive element, any art-recognized equivalent variable reactive element would have been usable therewith such as that of Shenai."

As pointed out by the Examiner in FIGS. 8a, 8b Sokal does not teach or suggest electronically tunable reactive devices. He does not describe his variable capacitor or inductor as having capacitance or inductance that varies with bias and with signal level, as would be the case for electronically variable reactances subject to large input signals. Thus, one of ordinary skill in the art would understand his variable capacitor and variable inductor as being standard mechanically variable reactive elements, as found in many

ordinary tunable electronic devices.

In a mechanically variable capacitor, the plates are moved to change the capacitance. The capacitance depends on the position of the plates but in any position the capacitance is independent of the applied voltage. In essence, the variable capacitor becomes a fixed capacitor once the operator stops moving the plates. Consequently, one can apply a signal of any amplitude (short of breakdown, of course) and will see the same capacitance. Because in any position of the plates the capacitance is fixed and independent of the applied signal voltage, there will be no distortion of the applied waveform by the mechanically variable capacitor.

In an electronically variable capacitor, the capacitance depends upon the instantaneous voltage (sum of bias voltage and instantaneously varying RF voltage) applied to it. Unlike a mechanically variable capacitor, an electronically variable capacitor does not become a fixed capacitor after one changes its value. While a mechanically variable capacitor will provide a capacitance that is independent of signal strength, this is not true for an electronically variable capacitor. Thus, while there is little difference in operation between small-signal and large-signal operation for mechanically variable capacitors, there is an important difference in operation for electronically variable capacitors.

In small-signal operation, the bias voltage is significantly larger, perhaps ten or more times larger, than the RF voltage. The RF voltage has little effect upon the capacitance of the electronically variable capacitor, which is substantially controlled by the much larger bias voltage. Thus, for small signals, the capacitance is essentially fixed as far as the RF is concerned, so the output RF waveforms are negligibly distorted by capacitance variation, and the harmonics produced are low. Previous uses for electronically variable reactive components are in small-signal applications in which the amplitude of the RF signal is a small fraction of the bias voltage or bias current so nonlinear variation is insignificant. This small signal mode of operation is used in the voltage-controlled oscillators, phase shifters, and small-signal tunable filters.

In large-signal operation, the RF voltage is now an appreciable fraction of the bias voltage (more than 1/10). The capacitance of the electronically variable capacitor now varies in response to the varying large signal RF voltage. This means that capacitance of the electronically variable capacitor varies within the RF cycle as the RF swings positive and negative. While the bias voltage is still used to control the capacitance, the average capacitance now depends upon both the bias and the amplitude of the RF. And the instantaneous capacitance is varying with the RF input signal. The output RF waveform is significantly distorted because of the variation of the instantaneous capacitance with time varying magnitude of the input RF signal, and therefore, significant harmonics are produced.

Varactor diodes have been used with large-signals for intentional production of those harmonic signals. In a frequency doubler, for example, a signal of frequency f is driven into the varactor through one filter and a signal at frequency 2f is extracted from the varactor through another filter. This is frequency multiplication, not power amplification. But this use illustrates the point that one of ordinary skill would be averse to using an electronically tunable capacitance for a power amplifier.

The electronically variable inductor has an analogous situation. It is controlled by current. The magnetic flux that circulates in the inductor is produced is a sum of bias and RF currents, leading to the same effects for electronically tunable inductors that would not occur for mechanically tunable inductors.

Thus, in providing for a power amplifier, that amplifies input signals having large signals, it would not be obvious to substitute electronically tunable capacitors and inductors for mechanically tunable capacitors and inductors. One of ordinary skill in the art would have expected that using an electronically variable reactive tuning device would result in signal distortion and production of significant power at harmonic frequencies, resulting in non-linear amplification and inefficient production of power at the desired frequency. One would conclude that linear amplification would be impossible.

Therefore, applicant would respectfully ask the Examiner to consider that one cannot simply drop an electronically variable reactance into the place of a conventional mechanically tuned reactance in a power-amplifier circuit. If in Sokal's power amplifier, mechanically variable capacitor C4 in FIG. 8b was replaced with Shenai's MMDC, the wave form would be distorted and significant harmonic power would be produced at the output, reducing the useful efficiency of the amplifier significantly. One of ordinary skill would recognize that merely substituting Shenai's electronically variable capacitor for Sokal's mechanically variable capacitor won't work. Thus, it is not obvious to combine the references. For the electronically variable capacitor to work in Sokal's circuit recognition that the problems can be overcome and additional invention are needed. It was applicant who provided that recognition and that additional invention.

While one of ordinary skill would have thought the suggestion of an electronically tunable power amplifier unworkable because of the nonlinear effects produced by variation of the electronically variable components with signal level, applicant recognized that the non-linearity problem posed by electronically variable reactances could be overcome and that such electronically variable reactances could be used in a power amplifier. Applicant was first to recognize that electronically variable reactance behave adequately as reactive elements in an amplifier, and that a substantial portion of unwanted harmonics could be filtered to provide a desirable output.

In addition, even without the concern about non-linear effects, the present

applicant recognized that one cannot merely drop Shenai's MMDC into Sokal's circuit and expect the circuit to work in a power amplifier. The present applicant provided additional circuit components to make the electronically variable reactances work in a power amplifier. As shown in FIG. 2 of the present application, he recognized that dc-blocking 31, 36 for electronically tunable capacitors 32, 37 and bias-feed components 33, 38, permit bias and control to be applied to the tunable component in a way that does not interfere with the high-power RF signal. Simlarly, dc-blocking 55A, 55B, and 55C for electronically tunable inductor 56, and bias-feeds 33 53, 57 are shown in FIG. 4. Also, dc-blocks 236, 237, 238, 239 for electronically tunable capacitors 232, 233, 234, bias-feed components 240, and RF-bypass 242, 246 are shown in FIG. 22. While these components do not overcome the problem of non-linearities, they do show that the combined references were not enabling as to how to provide the electrically tunable reactive element in Sokal's circuit. Further invention was needed just to make it work, even without addressing the non-linearity issue, and the present inventor was first to provide that further invention.

Second, the present inventor further realized that the nonlinearities were not entirely a show-stopper. For example, the present inventor realized that a harmonic component that is 20 percent of the amplitude of the fundamental causes significant distortion of the waveform, but constitutes no more than 4 percent of the power. Thus one can operate a power amplifier with an electronically variable reactance that is inherently nonlinear and at the most have a small reduction in the efficiency and output at the fundamental frequency of interest.

Third, the present inventor disclosed techniques for reducing or avoiding effects of the non-linear electronically variable reactive element. His novel solution was to use conventional reactances to trap the harmonics so that they don't reach the output or cause interaction of two nonlinear devices. He included at least one conventional component between the electronically tuned component and output to keep harmonic levels down. Thus, the output signal has reduced effect from the non-linear portion of the electronically tunable reactance, and there is minimal distortion of the output signal.

For example, a conventional inductor presents a high impedance to the harmonics, thus preventing significant harmonic current from flowing through. A conventional capacitor analogously presents a lower impedance to a harmonic, thus shunting it to ground.

One implementation of this technique is shown in FIG. 3, where conventional tuning capacitors 41 and 45 isolate electronically variable inductor 42 from output 28 and active device 20.

Another implementation is in FIG. 4, where conventional tuning capacitor 51

isolates electronically variable transmission lines 52 and 56 from active device 20.

In FIG. 7, fixed filter 70 isolates electronically tuned filter 11 from load 19.

In Fig. 15, conventional capacitor 130 and inductor 131 isolate electronically tuned filter 132 from active device 20.

In Fig. 22, conventional tuning inductor 230 isolates the voltage-variable capacitance of MOSFET 232 from the voltage-variable capacitance of MOSFET pair 233 and 234. Conventional tuning inductor 231 isolates the voltage-variable capacitance of MOSFET pair 233 and 234 from output 222 (which is coupled through transformer 221). Fig. 22 is the best example and represents an actual circuit which the present inventor built.

These figures illustrate a few of many possible configurations. Alternatively, the load may include a reactance that serves this purpose (e.g., the inductance in a loud speaker).

Thus, the rejections of claims 1-9, 13-19, and 28, 30-34, 37, 38, 40-46, and 56-61 under 35 U.S.C. § 103(a), as being unpatentable over Sokal in view of Shenai have been traversed.

As to claim 2, absent the invention described in the present application it would not be obvious how to adapt the output network to be tuned to a selected frequency in view of the capacitance or inductance of the power amplifier itself varying with the signal. It was the present inventor who taught how to accomplish this, as described herein above.

As to claim 3, absent the invention described in the present application it would not be obvious how to match load impedance in view of the capacitance or inductance of the power amplifier itself varying with the signal. It was the present inventor who taught how to match load impedance with an electronically variable reactance that itself varies with the signal, as described herein above.

As to claim 4, absent the invention described in the present application it would not be obvious how to produce a modulated signal with the output network in view of the capacitance or inductance varying with the signal. Applicant would note that prior-art power amplifiers produce amplitude-modulated signals by either (a) amplifying a signal that is already amplitude modulated or (b) varying the supply voltage. However, there was no teaching or suggestion in the references or in any other prior art of which the applicant is aware, that the electronically tuned output network can introduce modulation into the signal, as described in claim 4. This is entirely new, and this technique has

significant advantages in both bandwidth and amplifier efficiency, as described in the specifications section (starting at the middle of page 10 under "modulation" and continuing through page 17). The process is shown clearly in Fig. 9 and to a lesser extent in Fig. 5. One skilled in the art would not have envisioned the use of conventional variable reactances for modulation of the amplifier because they are far too slow with their rotating shafts and motors, since modulation requires changes at rates from several kilohertz to tens or hundreds of megahertz. These rates can be achieved by electronically variable components, but not by conventional components, and applicant was first to teach how to accomplish modulation using electronically variable reactances.

As to claim 5, which is dependent on claim 4, absent the invention described in the present application it would not be obvious how output network can be adapted to provide a power-amplifier load-impedance locus that substantially maximizes power-amplifier average efficiency. Applicant would respectfully ask the Examiner to consider that this goes beyond maximizing the efficiency for one particular output as one would by adjusting to match a load impedance. Rather it is selecting a locus of impedances that gives a good average impedance for a modulated signal. In accomplishing this selection, the locus must be a good compromise between providing amplitude variation and efficiency.

It is believed that the claims are in condition for allowance. Therefore, applicant respectfully requests favorable reconsideration. If there are any questions please call applicant's attorney at 802 864-1575.

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